# RECONFIGURABLE RESONANT AND LEAKY-WAVE ANTENNAS FOR FUTURE WIRELESS SYSTEMS

by

**Shu-Lin Chen**

Supervisor: **Prof. Yingjie Jay Guo**

Co-supervisor: **Dr Pei-Yuan Qin**

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School of Electrical and Data Engineering
Faculty of Engineering and Information Technology
University of Technology Sydney
Sydney, NSW 2007, Australia

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## ABSTRACT

Reconfigurable antennas (RAs), which have agilities in their frequency and radiation characteristics, are emerging as one of the key enabling components for wireless systems. Compared with single-function legacy antennas, RAs can greatly enhance the system functionalities and flexibilities. In this dissertation, on the basis of state-of-the-art of RAs, a thorough investigation, development, and implementation are conducted on reconfigurable resonant and leaky-wave antennas to fully exploit and extend the benefits of RAs.

In order to enable advanced technologies for reconfigurable resonant antennas, challenging and promising gaps associated with novel designs are addressed on polarization-reconfigurable antenna, pattern-reconfigurable antenna, as well as combined polarization- and pattern-reconfigurable antenna. In particular, a reconfigurable center-fed shorting-via loaded patch antenna is designed that can switch among four linear polarizations at a 45° rotation. Furthermore, by reconfiguring parasitic striplines and bottom reflecting metal pieces around a radiating dipole, five switchable beams including broadside, titled, and endfire directions, are achieved. Finally, a cavity-backed proximity-coupled patch antenna operating at 11 GHz is designed and reconfigured to switch among three linear polarizations, and its main beam can be steered to about $+20°$, $0°$, $-20°$ with a measured gain variation between 7.2 and 8.1 dBi for each polarization.

As one of the most widely used types of non-resonant antennas, leaky-wave antennas (LWAs) serially leak power through open traveling-wave structures, and they generally have inherent beam scanning capability by sweeping the source frequency. One main challenge in LWAs is to realize a wide-angle continuous

circular-polarization (CP) beam scan. A novel benzene-ring-shaped slot-loaded CP substrate-integrated-waveguide LWA with partially reflecting wall vias is developed herein to scan a CP beam from $-42.8^\circ$ to $+54.3^\circ$ with a gain variation of only 3.3 dBic. Moreover, a polarization reconfigurable LWA that can switch between its circular-polarization and linear-polarization states is investigated and accomplished to further improve the diversity and functionality delivered by the LWA system. Finally, to eliminate the frequency-dependant beam scanning behaviour, a reconfigurable composite right/left-handed (CRLH) LWA is developed that facilitates fixed-frequency continuous beam scanning over a wide operational frequency band.

Since the wireless systems are evolving towards multi-functionality to enable fast, secure, and reliable connections, it is believed that the developed reconfigurable resonant and leaky-wave antennas can find wide applications in current and beyond wireless systems.

## CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Shu-Lin Chen declare that this thesis, is submitted in fulfilment of the requirements for the award of the degree of DOCTOR OF PHILOSOPHY, in the Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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*To My parents*

&

*Brother and sister*

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# Acronyms

| | |
|---|---|
| AR | Axial ratio |
| CP | Circular-polarization |
| CRLH | Composite right/left-handed |
| EMC | Electromagnetic compatibility |
| EMI | Electromagnetic interference |
| HPBW | Half-power beamwidth |
| LHCP | Left-handed circular polarization |
| LP | Linear-polarization |
| LWA | Leaky-wave antenna |
| MIMO | Multiple-input-multiple-output |
| OSB | Open stopband |
| PRW | Partially reflecting wall |
| RA | Reconfigurable antenna |
| RHCP | Right-handed circular polarization |
| SIW | Substrate-integrated-waveguide |
| SSPP | Spoof surface plasmon polariton |
| UAV | Unmanned aerial vehicle |
| 1-D | One-dimensional |
| 3-D | three-dimensional |
| 5G | Fifth-generation |